TRIP A

GLACIAL FEATURES IN THE VICINITY OF TROY, N. Y.

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INTRODUCTION

During the past 60 years, the Hudson-Champlain Valley has periodically received the attention of several glacial geologists. This valley, the longest and most continuous north-south lowland in the northeast, was considered a valuable area for field study because it connected the terminal moraines of Long Island with the St. Lawrence Valley. For many years workers believed that a continuous record of Wisconsin ice withdrawal northward from Long Island was indicated by the many kame terraces, deltas, and lacustrine clays exposed throughout the Hudson Valley.

The north-south trend of the valley also proved ideal for the study of glacial rebound, and this phenomenon occupied an important place in the works of Peet (1904), Woodworth (1905), and Fairchild (1918).

Only recently (Flint, 1953),(MacClintock, 1954) have the deposits between the Hudson Highlands and Glens Falls been assigned to the Cary Substage, younger than the Tazewell Long Island moraines. (See Plate I) This assignment has invalidated the correlation of Lake Albany and the Mohawk delta with Lake Iroquois, a supposition basic to the early descriptions of regional history. In effect, the time during which the Hudson Valley was deglaciated has been considerably shortened from original concepts, although many local details are still valid.

Among the controversial problems was the nature of the water bodies which formed during ice wastage. Most workers accepted the importance of a pre-glacial Hudson gorge as a topographic low capable of retaining a long N-S tongue of ice in the valley contemporaneous with the lacustrine deposition. Peet and Woodworth were impressed by the evidence for a definite northward receding ice margin defending expanding fresh water lakes, while Cook postulated the superglacial accumulation of much of the valley deposits upon and next to a large saucer-like block detached from any south-facing regional block or lobe.

Fairchild, by not conceiving of a possible southern barrier isolating the valley from the Atlantic, postulated the marine invasion of the Hudson-Champlain region and related all of the depositional landforms throughout the valley to this sea-level strait. By passing his "ideal marine plane" through the average of the summit elevations of deltas, terraces and beaches, he determined the rebound value for the region to be 2.25 feet per mile, a figure too low by comparison to the 4.2 feet per mile value determined in the Connecticut Valley (Flint 1953).

Progress in the understanding of the glacial history of the Hudson Valley has been hampered by the lack of mapping. The only quadrangles which have received attention are the Schenectady (Stoller, 1911), Saratoga (Stoller, 1916), Cohoes (Stoller, 1918), and the Troy (LaFleur, 1960) 15 minute sheets.

HISTORICAL REVIEW

Early papers by Peet (1904), Woodworth (1905) and Fairchild (1918) were devoted to regional analyses of the Hudson-Champlain Valleys. Peet was the first to recognize the rebounded condition of the crust as indicated by the gradual climb of delta and terrace summits northward. He also called attention to no fewer than 15 places between Catskill and Glens Falls where the ice margin was indicated by distinct "morainic phenomena". His examples in the Troy area are the Schodack Terrace, Loudonville Moraine, and the Sycaway Terrace. Peet presumed that all of the Hudson Valley deposits dated from the withdrawal of a single Wisconsin ice sheet and hence assigned too long an interval to the Hudson waters, equal to the duration "of Lake Maumee, Whittlesey, Warren, Dana, and part of Iroquois."

Woodworth (1905) followed with a classical paper on glacial deposits and history of the Hudson-Champlain Valley, much of which is still valid. He called the "Hudson waters" of Peet by the name Lake Albany, following the application by Ebenezer Emmons and Asa Fitch (1849) of the name Albany to the clays of this area. In Fitch's words, "As neither its geological age or name is well settled, I prefer designating it the Albany clay". Woodworth correlated Lake Albany in part with Lake Iroquois, defining the former as a fresh water lake defended by the ice margin and progressively enlarging northward until the ice margin receded far enough to clear the Mohawk Valley for outflow of central New York waters (Lake Iroquois). At this time Lake Albany "properly came into existence". Woodworth also noted evidence for a readvance of ice into the Fort Edward area, and cited the several terraces of the Hoosic delta as evidence for the stages of lowering of Lake Albany.

Fairchild in 1912 accepted and restated the genesis of Lake Albany as postulated by Woodworth, and in the Mohawk Valley defined Lakes Schoharie and Amsterdam. He assigned the 340' Mohawk delta to Lake Albany and discriminated two periods of Mohawk Valley river flow: (1) the Glaciomohawk which drained: the later Lake Vanuxem, the free drainage succeeding Vanuxem, the restored Vanuxem, and Lake Warren; and (2) the Iromohawk which drained Lake Iroquois. Fairchild recognized that the relation of Lake Albany to the glacial Mohawk is not clear and suggested that it was probable Lake Albany endured to the close of Iroquois time.

Stoller in 1911 published his mapping of the Schenectady quadrangle, followed by the Saratoga sheet in 1916, and by the Cohoes sheet in 1918. His was the only mapping attempted in the Hudson Valley until very recently.

Fairchild in 1914 and 1918 rejected Woodworth's original conception of the Hudson waters, and assumed that all water-level-indicating features such as beaches and deltas were built in a body of sea level water extending from New York City to Canada, accompanying the receding ice margin. He passed an "ideal marine plane" through the summit elevations of the beaches and deltas and arrived at a figure of 2.4 feet per mile as a rebound value for the Schenectady-Saratoga area.

Stoller (1918), on the Cohoes quadrangle, recognized the presence of a series of water levels to the north of Troy and assigned them to stages in the lowering of Lake Albany. He did not side completely with either Woodworth or Fairchild on the genesis of these waters, and was more concerned with evaluating local conditions. He promoted Woodworth's conception of a narrow ice block occupying a sharply defined preglacial Hudson gorge contemporaneous with the deposition of clays between the ice and the shore in early Lake Albany time. Stoller separated the terraced lacustrines into (a) constructional surfaces (minimum elevation 300 feet) formed while ice occupied the central gorge; (b) construction surfaces marking the upper limit of fine sedimentation in the center of the valley following the melting of the ice block in the gorge (minimum elevation 240 feet); (c) fluvial erosional surfaces marking pauses in the lowering from the 360-foot maximum (200-foot upper level near Mechanicville, and 100 foot lower level, also near Mechanicville). He inferred that the Iroquois-Mohawk drainage emptied into Lake Albany through the Anthonykill channel at Mechanicville when the lake waters were at the lower 100-foot terrace level. He rejected Fairchild's marine strait on the grounds that (a) no evidence exists indicating rising water levels following the cutting of the erosional terraces by existing waters, and (b), the marine strait would have to occupy a very narrow channel.... "at Mechanicville not greater than approximately the space between the 100 foot contour lines on the opposite sides of the valley; that is a breadth not greater than that of the present valley bottom".

In 1922 Stoller restated a 360-foot level for the maximum development of Lake Albany in the Cohoes latitude and correlated the 300-foot Malta sand delta and the 310-foot Saratoga delta with stages in the lowering of Lake Albany.

In the first of several papers, Cook (1924) treated the hypotheses explaining the disappearance of ice from eastern New York, and was impressed with the lack of concentrically arranged recessional moraines as compared with those of the Erie Lobe in Ohio and Indiana. He proposed that the portion of the ice sheet south and east of the Adirondacks wasted by the stagnation vertically of an overthickened block, a condition invited by a saucer-like crustal downwarp of a moderately rugged area. Cook also considered that the ice in the Hudson Valley was thicker than elsewhere and as a result lingered until after the termination of lacustrine conditions. He promoted Woodworth's concept of an ice block in the Hudson Valley contemporaneous to part of Lake Albany and extended this concept by suggesting that the Hoosic and Battenkill deltas (Cohoes and Schuylerville sheets) were built over blocks of ice at the time of maximum development of Lake Albany. He was led to this conclusion by not encountering any levels coincident with the terraces of the Hoosic delta elsewhere in the Hudson Valley. Cook opposed the concept of a well-defined southward-facing ice margin, connected to live ice, retreating northward as melting progressed. Of particular importance was the following observation:

> "This much is evident; all of the clays in the valley north of Rondout do not belong to a single water body which may be called Lake Albany; some of them were laid down in ponded water marginal to the ice tongue filling the main valley and parts of the smaller valleys tributary to it." (p.174)

Cook also believed that...."There is much to suggest that Lake Albany was combered with ice, both floating and anchored in the gorge, that cobble-covered ice formed the bed of its outlet for many miles and that this protected ice in the lower valley existed contemporaneously with the buried masses in the upper valley already mentioned, as long as this "lake" endured." (p. 174)

Brigham (1929) discussed the glaciation of the lower Mohawk Valley, but his work did not extend east to the Troy area. He estimated the maximum thickness of ice over the Capital District to be 3700 feet, to permit glaciation westward through the Mohawk Valley, ascending to near the 1600 foot level of the plateau at Cedarville in Herkimer County.

Cook (1930) in Ruedemann's "Geology of the Capital District" called attention to the moraine on the Troy quadrangle (Albia-Burden Lake moraine of this paper) and considered the Schodack terrace to be totally an ice-margin deposit, continuing to the south through the Kinderhook sheet. Cook did not recognize any beaches, especially along the Schodack terrace, and therefore eliminated from consideration ice-free conditions for Lake Albany.

Rich (1935) mapped the glacial deposits of the Catskills and was the first to recognize drifts of two different ages, which were later correlated by Flint (1953). Rich's mapping borders on the Hudson Valley, some 30 miles south of Troy.

Chapman (1937) discussed the deglaciation and lake stages of the Champlain Valley and, pertinent to the Troy area, he (1) dismissed completely Fairchild's marine invasion from the south, (2) proposed that no tilting (rebound) of the region occurred from early Coveville time until the marine invasion from the north, and (3) proposed a gentle uplift and tilting during the final stages of Lake Albany.

Cook added chapters on the glaciation of the Berne (1935), Catskill (1942), and Coxsackie (1943) quadrangles, all to the south and west of the Troy area, but he did not map any of these areas. Cook repeated his hypothesis of ice stagnation and selected local deposits and landforms as evidence. He continued to reject the ice-wall theory of retreat, and emphasized the importance of superglacial drift accumulations and ice-contact topography. He assigned the clays to a series of lakes and times of deposition rather than a synchronous "Lake Albany", but did not attempt to arrange water bodies in either a geographical or chronological order.

Chadwick (1944) cited evidence for the presence of an ice block lingering in the Hudson Valley beneath Lake Albany waters in the Catskill area and also considered the possibility of progressing wave-or bulge-type rebound holding in the waters of Lake Albany at the south. He cited the northward deflection of part of the clay plain in the Catskill area as evidence for a 4.5 foot per mile rebound value instead of the 2.25 foot per mile value measured on the shorelines in the same area.

Cook (1946), in a paper on ice-contact deposits, selected landforms from the Troy area as examples. He cited the large hill east of Rensselaer (in the present paper, Plate II, called "Rensselaer Delta") as an example of a "smooth rounded" type of ice contact, in which an arch-shaped overhang of ice has determined the curvature of the hill on the upstream side. He illustrated the Schodack terrace as an ice-contact deposit with an ice roof overhang bordering the terrace along its western edge.

Cook (1946) coined the words "kame-complex" and "perforation deposit", and applied them to features which he had observed near Urlton on the Coxsackie quadrangle.

The most recent regional synopsis has been provided by Flint (1953) and his conclusions are summarized as follows:

1. The lacustrine clays and silts of Woodworth's Lake Albany are not overridden by readvancing ice between Newburg and a point a few miles south of Glens Falls, but are overridden farther north.

2. "They are not covered with outwash but are the latest glacial deposits in the valley." (p. 902)

3. Lake Hackensack and Lake Albany lacustrines are distinct, separate sedimentary bodies, although Antevs (1928) correlated Lake Albany varves at Newburg with those in the Connecticut Valley.

4. Outwash covering undisturbed Lake Hackensack clays suggests an ice margin at the Hudson Highlands prior to Lake Albany.

5. Lake Hackensack is correlative with the retreat of Tazewell ice; Lake Albany dates from the retreat of the Cary ice margin.

6. There is a discrepancy in the rate of northward rise between the 4.2 feet per mile value for the Connecticut Valley, and 2.25 feet per mile for the Hudson Valley, as measured from sediment summits between Newburg and Glens Falls.

7. The possibility of Cary readvance, at any latitude, between Glens Falls and Newburg is eliminated.

8. The readvance of ice near Glens Falls dates from the Mankato substage.

9. Lake Albany was drained in Cary rather than Mankato time, to permit marine invasion in the deglaciated St. Lawrence lowland.

10. The Mohawk discharge into the Hudson Valley dates from Lakes Whittlesey and Vanuxem (late Cary) rather than Mankato.

11. The two drifts of the Catskills may possess substage value;...

    "the younger drift in the Catskill Mountains district is the Cary drift, and ....the subdued topography and the weathering of the older drift are a record of the Brady interval." (p. 904)

12. A rising lake level, not yet recognized, prior to Chapman's Lake Vermont, accompanied the receding Mankato ice north of Glens Falls.

13. The Lake Vermont Glens Falls delta may cover the evidence of Mankato advance west of Glens Falls.

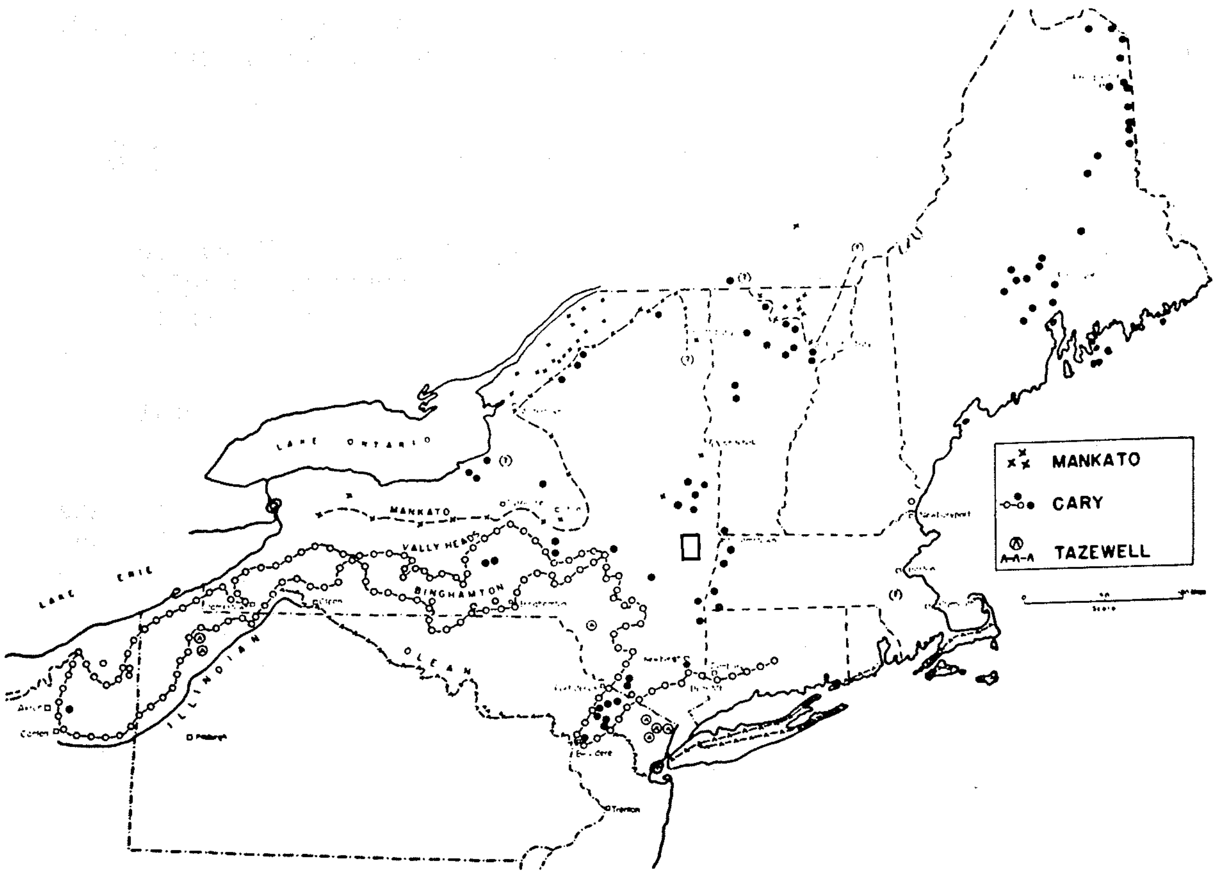
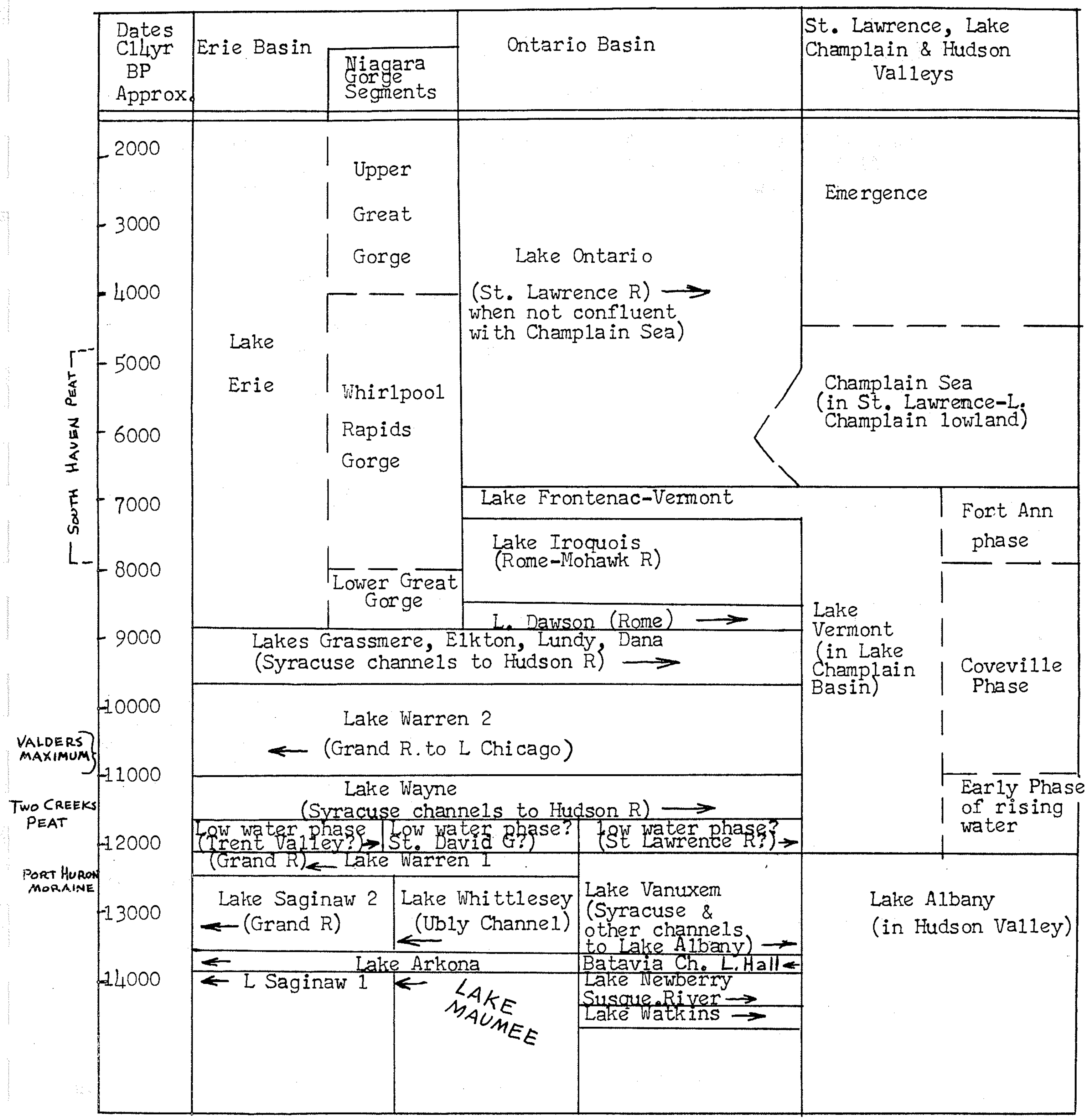


PLATE I. Map Showing Carbonate Leaching Test Localities And Proposed Drift Correlations. From MacClintock (1954). Troy Quadrangle Indicated By ▯.

MacClintock (1954) correlated drift by depth of carbonate leaching, and for the Hudson Valley postulated that the younger Catskill drift of Rich is Cary in age. Plate I is his map. Note the abundant sample localities indicating Cary age surrounding the Troy area and also the two localities near Glens Falls and Saratoga with a Mankato age designation. The extent of Mankato advance into eastern New York has not been established.

The present author (1960) has mapped the Troy quadrangle, and the "Sequence of Events" chart, Plate II, and the remainder of this discussion are based on this work.



"SEQUENCE AND MUTUAL RELATIONS OF THE LATE-WISCONSIN GREAT LAKES". Eastern part of table, from Flint (1957).

GENERALIZED SEQUENCE OF EVENTS

DECREASING AGE

CARY SUBSTAGE

Episode	Features on Troy Quadrangle
Dissection of lacustrines by present Hudson River.	
"Lake Albany" lowered to 180'	Glacial rebound of 340' Lake Albany beach
"Lake Albany" lowered to 230'	Minor beaches west of Rt. 4 and B & A R.R.
"Lake Albany" lowered to 310'	Highland Ave. sand - Griswold Hgts. delta at Troy, 310' summit. 310' Wynantskill terrace
Lake Albany max. 340'	Blooming Grove and Schodack terrace beach ridges, Defreestville beach, Frear Park beach, Troy Airport 340' summit sand delta of the Wynantskill
Rising water from ice-free Mohawk (?)	Clays exposed on Spring St. & Highland Ave., Troy
Rensselaer-Albany Interval Possible lowering of lake levels to about 320'.	Ice-margin deltas north of Troy on Cohoes sheet. Clay deposition (?) in Troy area Rebound-induced deflection of upland drainages southward.
Lake Rensselaer 300' + (350'?)	"Rensselaer delta" east of Rensselaer, clays south of Rt. 381. Ice-border gravels (?) along Rt. 4
Lake Hampton 350'	"Hampton Park delta", kettle fillings on Schodack Terrace @ East Greenbush. Clays and sands west of Couse and south of Sherwood Park. Superglacial portion of 380-360 cobble-gravel terrace in North Greenbush.
Lake Schodack 330'	Foresets of Schodack terrace. Clay & gravel bottomsets west of terrace front.
Schodack Terrace	Several continuous stages of gravel deposition as ice margin withdraws NW from Rt. 9 vicinity.
Albia-Burden Lake (and other) upland kame moraines	esker delta complexes

Emergence of Rensselaer grit plateau as a nunatak. High-level kames & deltas around edge. Stagnation and downwasting of ice toward west and north from western edge of plateau.

Formation of drumlins. Cary ice bifurcated at Helderbergs, sending the Mohawk lobe westward into Herkimer County. The Hudson lobe extended south to the Highlands (?) and southeastward into the Berkshires.

Pre-Cary erosional topography on Taconic rocks (and earlier drift?). Local relief frequently exceeded 200'.

GEOMORPHIC SETTING

The Troy quadrangle lies near the geographic center of the Hudson-Champlain lowland at its junction with the Mohawk Valley and displays the record of a single Late Wisconsin glacial advance and stagnation of probable Cary age. The surficial deposits are underlain by severely deformed Cambrian and Ordovician rocks of the Taconic sequence, mapped by Ruedemann (1930) and more recently by Elam (1960, unpublished; western half).

A relief of over 1500 feet extends from the tidewater Hudson River, bordering the area on the west, to the rugged plateau maintained by the Rensselaer graywacke on the eastern edge. Preglacial erosion developed a sharply defined topography with local relief frequently exceeding 200 feet on north-south trending structures in the less resistant shales and sandstones west of the Rensselaer escarpment. Drumlins are common throughout the area, with average summit elevations rising eastward from 450 feet near the Hudson River to 950 feet at the base of the escarpment. Some drumloid masses of thick bouldery till occur on the Rensselaer plateau but typical drumlins are restricted to lower elevations. Much of the western quarter of the quadrangle is underlain by lacustrine sediments heretofore assigned to Lake Albany, and by gravelly deltas and kame terraces, marginal to ice blocks lying in the Hudson preglacial channel. Beaches of Lake Albany extensively alter granular deposits from Frear Park in Troy south through Defreestville to the Schodack terrace. Postglacial gullying of the lake clays has severely dissected the westward-sloping plain bordering the Hudson River on the east.

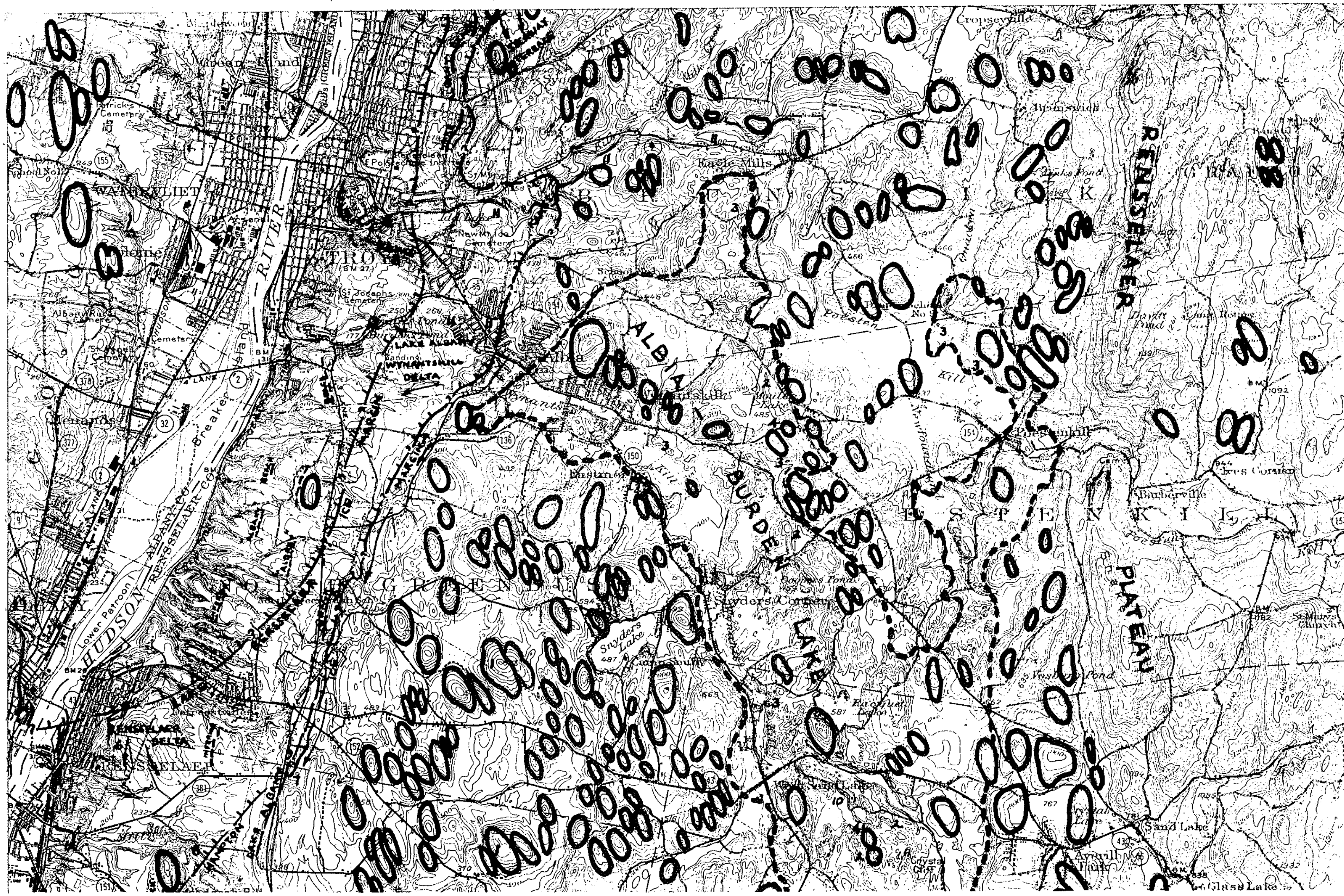
Two distinct topographic trends are developed. Ice advanced from N20W as indicated by drumlin axes. Where drift is thin the Taconic structural grain is dominant, striking N-S to N15E. The Troy area received the southeastern advance of ice as the main advance split at the Helderbergs, sending the Mohawk Lobe westward.

ICE ADVANCE FEATURES

Drumlins

Much of the Troy area west of the Rensselaer plateau is covered by clusters of drumlins. See Plate II. They are particularly abundant along Rt. 43 between West Sand Lake and Defreestville. The trip route will cross this area.

Composition of the drift closely reflects underlying bedrock. The trend of major Taconic lithologies nearly coincides with the direction of ice advance, making the evaluation of distance of transport of bedrock fragments by moving ice a difficult one. Generally the till is rich in clay, shale, and siltstones, and poor in carbonates. Near the base of the Rensselaer plateau some patches of till have a brownish or reddish color from the high content of red shale. On top of the plateau, the drift is generally thin and contains boulders of graywacke, some of huge proportions. Where the till is calcareous, it has been leached to a depth of about 5 feet, but the limestone content of the drift generally is low and irregular, and dating by the depth of leaching has its limitations.


RENSSELAER
PLATEAU
ALBANY
BURDEN
LAKE
LAKE ALBANY
WYNANTSKILL DELTA
RENSSELAER DELTA
HUDSON
RIVER
Breaker Island
Lower Patroon
WATERVLIET
TROY
Eagle Mills
Cropseyville
Brunswick
Snyders Lake
Snyders Corners
Defreestville
Barberville
Averill Park
Sand Lake
Glass Lake
West Sand Lake
Crystal Lake
Poestenkill
Wynantskill
St Marys Church
Newark Ida Cemetery

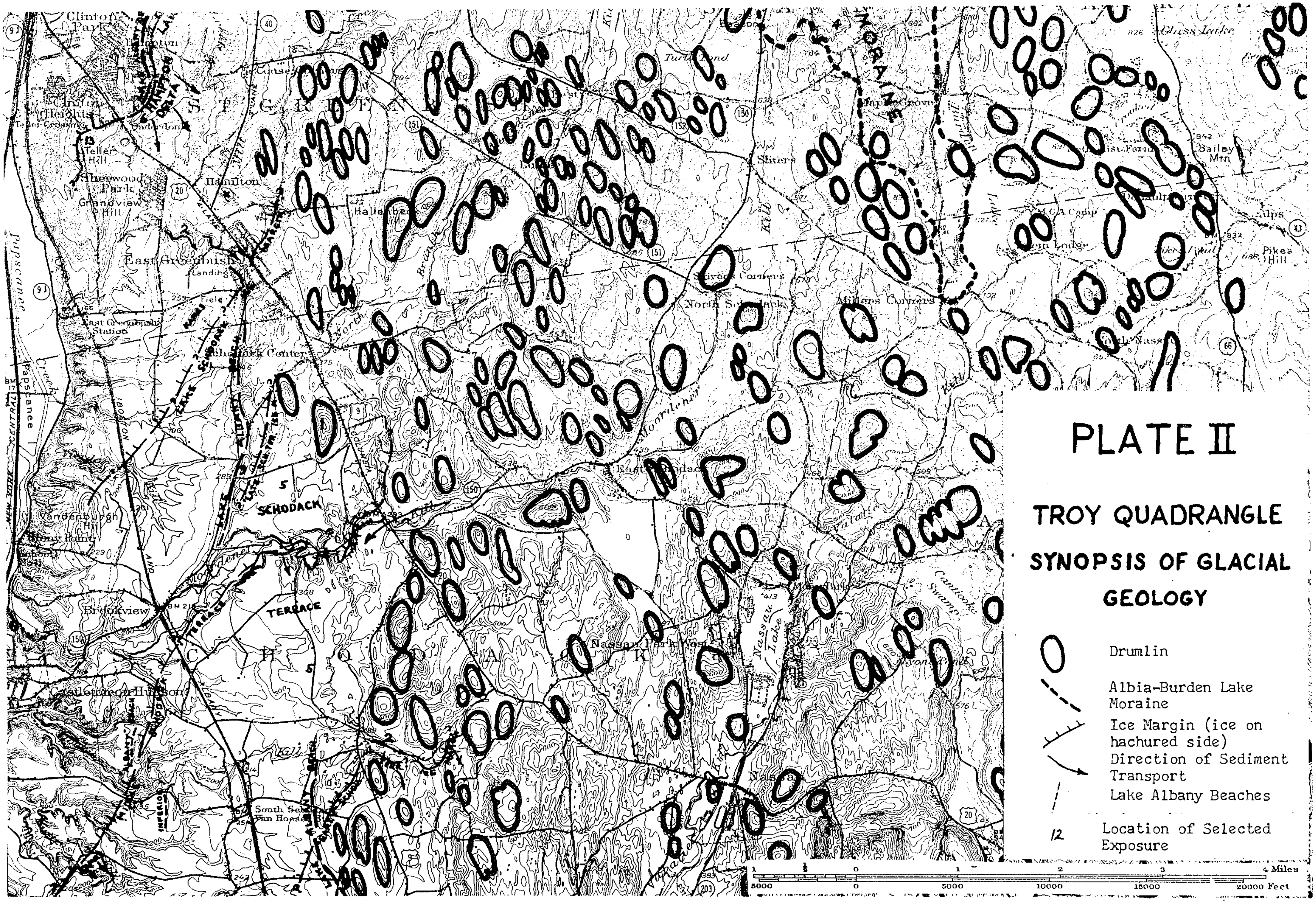


PLATE II
TROY QUADRANGLE
SYNOPSIS OF GLACIAL GEOLOGY
Drumlin
Albia-Burden Lake Moraine
Ice Margin (ice on hachured side)
Direction of Sediment Transport
Lake Albany Beaches
12 Location of Selected Exposure
Clinton Park
Clinton Heights
Teller Crossing
Teller Hill
Sherwood Park
Grandview Hill
East Greenbush
Hamilton
Hallenbeck
Schodack Center
SCHODACK
TERRACE
Vandenburgh Hill
Brookview
Castleton-on-Hudson
South Schodack
Van Hoesen
North Schodack
Millers Corners
East Schodack
Nassau Park West
Nassau Lake
Nassau
MORAINE
Glass Lake
Bailey Mtn
Alps
Pikes Hill
Papscanee
Miles
Feet

STAGNATION FEATURES

The Albia-Burden Lake Moraine

A continuous gravel moraine extends for 8 miles from Burden Lake north and west to Poestenkill and Albia. (See Plate II)

Isolated kames, kame complexes, eskers, and esker deltas are well developed throughout this area. Fundamental to the formation of this moraine was the ability of the ice block to temporarily maintain local base levels by withholding its runoff waters. Downwasting progressed northward (downhill) through a minor preglacial valley which joins the Hudson Valley south of Troy. Periodic halts in the retreat of the margin (acceleration in melting of the whole block while the margin is along any given line) produced semimentation both in front of the margin and in crevasses leading to the margin. As evidenced by the maximum length of the eskers which feed the ice-margin outwash, the ablation zone, as far as sedimentation is concerned, extended upstream no more than 2 miles from the margin. This distance seems to be rather consistent throughout the length of the moraine, and also is appropriate to the ice margins of the more central Hudson Valley.

Within this moraine, summit elevations of eskers and esker deltas decrease (750 feet to 400 feet) progressively from SE to NW. Temporary locations of the ice margin are indicated at the following locations: one mile NW of Maple Grove; one mile WNW of Crystal Cliff; at West Sand Lake; one mile NW of Racquet (Reicherts) Lake; at Coopers Pond-Pine Bowl Speedway; and at Pawling Sanitarium - Moules Lake, where the ice margin can be traced into the Poestenkill valley along Route 354 and thence southeast along the Newfoundland Creek valley.

Apparently there was no barrier to surface water communication between the Poestenkill Valley and the ice margins listed above. Trend of differentially eroded bedrock is favorable, and a large area of bare rock with patches of gravel extends from near Racquet Lake NE to Newfoundland Creek. If one can presume that summit elevations of ground-laid outwash lying at the same elevation are built under the same local base levels and hence are nearly contemporaneous, then various portions of the moraine can be correlated. A paucity of outwash levels from 820' to 620' exists for the Poestenkill Valley while several levels within that range occur toward the Burden Lake end of the moraine. Consequently a northward retreat of the ice margin would have covered 3 miles between Burden Lake and West Sand Lake, while at Poestenkill the margin was withdrawing only one mile westward between Brookside Cemetery at Barberville and Poestenkill.

For the vicinity of the Albia-Burden Lake moraine it may be stated that the ice frequently presented a discernible south-facing margin and, as is further shown in the section on Hudson Valley lacustrine stages, this tendency was maintained at least through the time of the Newtown Road delta, on the Cohoes sheet to the north of the Troy area. This would seem to refute Cook's (1924) preference for a detached ice block in the middle Hudson Valley, apparently unrelated in its melting to any general northward withdrawal of the ice margin.

As may be noted from the $7\frac{1}{2}$ minute topographic sheets and also in the field, both the longer eskers with their usual periodic sags and the shorter single-segment eskers rise to their outwash termini by as much as 60 feet. This suggests that the eskers did not accumulate in subglacial tunnels but rather that they have collapsed from an englacial or supraglacial position from which they fed the outwash plain as base-level controlled, ice-fracture-directed streams. Those longer eskers which followed crevasses in the ice parallel to original ice advance generally rise less to the outwash summit than do those shorter forms which follow directions at near 45 degrees to ice advance. The preferred interpretation is that the long eskers are deposited in early-opening crevasses, exposed to the sky, with sagging caused by differential collapse where the esker is locally laid over ice. Sedimentary structures of several long eskers indicate they are largely ground laid with foreset bedding being common.

The shorter eskers may have accumulated in late-opening crevasses immediately next to ice margin.

The Schodack Terrace

The Schodack terrace, named for its prominent development through the Town of Schodack, is an extensive area of gravel and sand, bordered on the north by an esker-fed kame complex near the village of East Greenbush, and merging 8-10 miles to the south with the similar but larger Kinderhook terrace. The Schodack terrace was first recognized by Peet (1904), and Woodworth (1905), who called it a kame-terrace with an ice-contact along its western edge. This designation was also followed by Fairchild (1918), and Cook (1930). In 1946, Cook attributed the rounded and smoothed western edge to contact with an ice margin which overhung part of the terrace toward the east.

Jahns and Willard (1942) noted similar ice-margin terraces in the Connecticut River Valley and pictured them as forming by stages beginning along ice margins but ending in delta foreset deposition into glacial lakes standing in front of the ice margin. The Schodack terrace appears to duplicate this sequence. In several pits, collapsed gravels are overlain by delta topset and foreset beds. West of the terrace edge, interbedded clays and sandy gravels encountered in water wells are probably the bottomset equivalents to the delta stage.

The western edge of the terrace rises from a gullied clay plain and has been altered by beaching of waters assigned to Lake Albany. Prominent beach ridges occur where the terrace faces westward or slightly north of west. Where southeast-trending borders are present, beaches are not so well developed. The western edge does not, in most places, reflect an ice contact, overhanging or otherwise, and the sediments beneath the beach are mainly westward-dipping delta foresets.

The terrace surface is gently rolling and frequently pitted by kettle holes. Its maximum elevation is 350 feet near the eastern edge where it is bordered by drumlins, and it slopes to about 320 feet near the beached western edge. Angular eskers are exposed within the terrace along the Moordener and Vlockie Kills and attain summits of 350 feet. Southeast of Brookview, between the Moordener and Vlockie Kills, the western edge of the terrace is indented by reentrants which are aligned parallel to the eskers exposed elsewhere on the terrace. Beaching between these points is slight and the reentrants could be unaltered ice contacts. South of the Vlockie Kill, the western edge is straight and capped by beach ridges. From south to north, the average terrace summit increases by about 10 feet, but it could easily have rebounded by that amount. The part of the terrace south of the Moordernkill probably is older than that part to the north, as evidenced by the eskers which feed the terrace at an ice contact along which this creek now flows. (See Plate II for locations of probable ice margins.) This suggests that the Kinderhook terrace to the south began to form before the Schodack terrace, as a south-and east-facing ice margin in the Hudson Valley progressively wasted northward. The "early", "middle", and "late" terrace ice margins are examples.

HUDSON VALLEY LACUSTRINE STAGES

The Lake Albany Problem

Originally it was suggested by Peet (1904) and Woodworth (1905) that the Hudson ice block defended lake waters on the south, and as its margin melted northward an increasing area was presented for the accumulation of lacustrine sediments, chiefly clay. These successive water bodies (or growing single body) have been called by the general and collective term Lake Albany. Mapping in the Troy area indicates that this concept of ice withdrawal is valid, and also that it is necessary to recognize the sequential lake stages that comprise the total "Lake Albany".

Two ice-margin deltas are found on the Troy quadrangle isolated from the kame terraces to the east. ("Hampton Delta" and "Rensselaer Delta" of Plate II). Reconnaissance of the Cohoes and Kinderhook sheets to the north and south has revealed other places at which the receeding ice margin also remained for a time long enough to deposit frontal gravel deltas with fine-grained bottomsets into standing lakes.

In addition to the two deltas on the Troy sheet, there are (1) numerous kame-terrace-delta deposits along the eastern edge of the main Hudson Valley which date from both deltas, and also from more southern positions of the ice margin; and (2) continuous and well-formed beaches which extend from the Kinderhook area north to the Schuylerville sheet. These beaches modify the western edges of both the kame-terraces and mid-valley deltas, and as a long fetch is required for the beach development, an ice-free condition for the Central Hudson-Eastern Mohawk Valleys during the later lake stages is indicated.

It is further necessary to define as accurately as possible those lake stages which coincide with the unblocking of the Mohawk Valley, in order to extend Hudson Valley correlations westward. The Albany-Troy-Schenectady area is critical to this problem.

The determination of glacial rebound values for eastern New York depends upon the dating of the beaches and other deposits on which measurements are made. There is abundant evidence in the Troy area that rebound was in progress during the ice-margin and ice-free lake stages. The grouping of all the valley deposits together and the averaging of the depositional summits has produced a total value of 2.25 feet per mile for the region, which is too low.

The sedimentary relationships also call for more precise definition of Lake Albany. The bulk of the clay can be related to the ice-margin lake stages more easily than it can be equated to the ice-free lakes. Deltas, some of them very large, cover clay in many areas. Frequently, as at the Schodack terrace and at the Hampton and Rensselaer deltas, clays are interbedded with silts, sands and gravels in bottomset relationship. Sand-and gravel-free clays elsewhere probably represent more distal bottomset occurrences of ice-derived sediment. Westward from the main Lake Albany beach, silts and pebble gravels have been carried lakeward over earlier clays, suggesting perhaps a minimum of clay was deposited in "later Albany" time.

Sequence of Glacial Lakes

ICE MARGIN STAGES

Three of many successive Hudson Valley lakes are recognized as having ice margins on the Troy quadrangle.. It is presumed that open waters extended to the south away from these margins, and that to the north, the Hudson lowland was filled by ice to a greater degree than at the Troy latitude during this time. (See Plate II)

The lakes are named Schodack, Hampton and Rensselaer in order of decreasing age. These are given names for the purpose of reference and description of local deposits. Further mapping is necessary to establish the degree of applicability of each. They are important to recognize, however, because it is likely that at some time during the existence of or shortly after these stages, the Mohawk was opened to eastward runoff by near final stagnation of the Mohawk Lobe.

Lake Schodack

Lake Schodack is postulated (1) to account for the delta foreset beds which dip generally westward along the western edge of the Schodack terrace, and (2) to collect the interbedded clay, sand and gravel which is encountered in water wells drilled along the terrace edge. The mid-valley position of the ice margin at this stage is not exactly known, but Strong (personal communication) of Hall, Inc., Delmar, N.Y., has postulated the western limit of gravel aquifers beneath the clay to pass due south from Grandview Hill. The persistent bedrock hogback beneath clay over which the streams entering the present Hudson now fall, nearly coincident with Strong's aquifer border, may have provided a logical place for the ice margin to linger during Lake Schodack time. A water level of 330 feet above present sea level would accomodate the delta beds and also permit filling of some of the kettles along the terrace edge shortly thereafter, but the dating of these kettle-fillings is uncertain. They may date from a later stage of Lake Albany, as evidenced by the increased thickness of beach gravels into contemporaneously collapsing shoreline kettles. Apparently Lake Schodack did not extend an eastern marginal embayment much farther north than Couse, where remnants of pebble gravels at 330 feet are exposed at the intersection of Routes 4 and 151. As yet no isolated marginal delta, supplied from the ice alone west of the Schodack terrace, has been found.

Lake Hampton

Lake Hampton, with a postulated water level of 350 feet is named from the prominent ice-margin delta upon which Hampton Park in East Greenbush is located. The delta summit corresponds to this level and about 10 feet of channeled topset beds overlying foresets are exposed in a gravel pit atop Hampton Park. The north end of the delta is defended by Rysedorph Hill, a small but bulbous knob of Rysedorph Conglomerate which served as a nunatak in the Hampton ice margin, probably inviting accelerated ice melting on its downstream side.

East of the delta along Mill Creek, sands which are traceable up the delta slope interfinger with clay, indicating open water in an embayment east and probably northeast of the delta. The near-level-bedded cobble gravels, which are continuously exposed from near Albia south to Defreestville at an elevation of 380-360 feet, terminate in delta foresets exposed in a pit at the intersection of Routes 4 and 381. These beds are in nice adjustment to a 350 foot level of Hampton lake water and are assigned to that body. Possibly these 380 foot gravels could be assigned to Lake Rensselaer, which follows, but relationships in the Wynantskill delta area are contrary to this association.

Lake Rensselaer

Immediately east of the City of Rensselaer, a drumlin-shaped hill nearly one mile long, surrounded by clay, attains an elevation of 300 feet. This hill, called the Rensselaer delta, contains southward-and southeastward-dipping pebble gravel foresets and bottomsets. Connected with this delta beneath, and exposed in the gully to the northwest, and through Rensselaer to the Hudson River, is the southeastern extension of the Loudonville moraine. The clays south of the delta, exposed along Mill Creek contain at least 50 percent sand, and may represent cyclical (turbidite?) bottomsets of the delta. There is no evidence that any of the delta is superglacial and no slump structures are encountered in the pit along its southwest flank. In the pit at the east end of John St., 2000 feet east of School 2. in the City of Rensselaer, slumped cobble gravels are exposed at 100-140 feet and may have collected under more superglacial conditions prior to the retreat of the ice margin to the north edge of the Rensselaer delta. Such a sequence would duplicate that of the later Newtown Rd. delta on the Cohoes sheet.

The level of Lake Rensselaer cannot be established exactly, but a northward retreat of 2 miles of the Hampton ice margin is indicated. A lake level of at least 300 feet is required, but as the Rensselaer delta has no topset beds, and as the lower 350-foot level gravels to the east adjacent and inferior to the 380-foot river gravels through North Greenbush are well-beached and altered by later waters, the upper limit of the lake can only be estimated to be near or slightly lower than the 350 foot Lake Hampton level. Further work is needed in Albany County before the significance of Lake Rensselaer and its ice margin can be established. This episode may have been the first one in which Mohawk water played an active part. The Loudonville moraine slightly antedates the Rensselaer delta and the geographic setting and large volume of the former suggests an unusually heavy influx of superglacial drainage into the ablation zone, possibly more from the west than previously. It would not be suprising if the ice-contact deposits of the Loudonville moraine dated from Lake Hampton, while the terminal Rensselaer delta represents the end of the retreat of the ice margin through the Hampton ice ablation zone.

Post-Rensselaer-Pre-Albany Interval

Well-defined frontal deltas are not found north of the Rensselaer delta on the Troy sheet. Gravels are exposed at Waterford and along Newtown Road in Saratoga County on the Cohoes sheet. The Newtown Road deposit is deltaic with a northerly source only on the final stages and is interlobate in early stages.

The channeled topset beds of the Newtown delta are overlain by congeliturbate clays. The summit of the Newtown deposit lies now at 350 feet and if rebound is taken even as a conservative $2\frac{1}{4}$ feet per mile, the delta's position - 13 miles north of the Hampton Park delta, at an identical elevation - would place the original summit level at a maximum of 320 feet if water levels had remained constant. While the value or the nature of rebound has not been established, the summit level of the Newtown Rd. delta suggests a general lowering of lake levels following Lake Rensselaer time. It is also likely that the ice margin became less continuous during this interval, under the influence of added drainage from the Mohawk. Further speculation on this interval is not warranted until more mapping is done to the north. Part of the clays north of the Rensselaer delta latitude belong to this interval, but how much is not presently known. The next recognizable episode is that represented by the persistent shore line of a redéfined Lake Albany.

ICE-FREE STAGES

Lake Albany

The name Lake Albany is redéfined and assigned to the broad, ice-free water body which produced the continuous beach with frequent storm ridges from south of the Troy sheet northward beyond the limits of the Cohoes quadrangle. This is the level (320 feet on the south edge to 340 feet at the north edge of the Troy sheet) Stoller has assigned to the maximum development of Lake Albany, which attained according to him a level of 360 feet on the Cohoes sheet, and to which the Hoosic delta summit was concordant. In the present writer's opinion, the use of the Lake Albany designation should be restricted to this level and episode.

At full development, Lake Albany received, in the Troy area, the discharge from the Wynantskill and Poestenkill Creeks where a 25-50' sand delta beneath the Troy Airport was constructed. (Wynantskill delta of Plate II). Discharge from the Mohawk (Lake Vanuxem?) presumably was responsible for the extensive sands exposed between Albany and Schenectady known as the Mohawk delta. Much of this deposit was later wind-worked into what is locally called the "Colonie blow sand".

Small patches of sand occur east of the Hudson as erosional remnants above the clays, and occasionally the sand contains rafted cobbles. Dunes in the Troy area are rare. Sand and pebble silt carried westward from the Lake Albany beach covers the earlier clays, particularly west of the Schodack terrace where sand thickness frequently exceeds 10 feet. How much clay was deposited in the redefined Lake Albany is not known but the deltaic materials laid over the clays suggest that, at least along the shore, coarse material dominates. It appears that most of the clay should be assigned to the earlier ice-margin lakes. Some clay in North Albany is clearly superglacial.

Lower Stages of Lake Albany

The Lake Albany ice margin at the time of the beach formation stood at least as far north as the northern edge of the Cohoes sheet but the degree to which the upper Hudson Valley was deglaciated at this time is not now known. Presence of deltas in the Schuylerville, area particularly that of the Battenkill, standing at levels inferior to the 360' Hoosic delta - 320' Albany beach, (at the Schodack latitude) may indicate 1) the ice filled the valley north of the Hoosic at this time preventing open-lake deltas from forming, or that 2) the inferior deltas record stages of sedimentation which occurred only during the lowering of Lake Albany. Minor beaches and deltas inferior to the Albany beach occurring at 310', 230', and 180' in the Troy area may prove correlative to some of these northern deltas. The Cohoes-Saratoga-Schuylerville area contains more evidence for the lower Albany stages than does the Troy area. Bedrock nickpoints occur in all the streams entering the Hudson south of Troy. The Hoosic delta terraces may provide the best data, as Woodworth (1905) and Stoller (1918) both pointed out.

SELECTED EXPOSURES

1. Drumlins. Dozens occur between the Wynantskill and Moordenerkill in the towns of North Greenbush, East Greenbush, and Schodack. Long axes trend about N20W. See Plate II.

2. Eskers. Many occur throughout the Alben-Burden Lake moraine. The most typical are at Moule's Lake, Coopers Pond, and West Sand Lake. Two others feed the Schodack Terrace at East Greenbush and along the Vlockie Kill. Esker deltas are extensively excavated 2 miles ESE of West Sand Lake.

3. Kames. Exposed along Rt. 66 SE of Wynantskill, south of Eagle Mills, and E. of the Wynantskill at West Sand Lake. Solitary kames occur one mile north of Poestenkill.

4. Ice contacts. Several ice contacts cross the Albia-Burden Lake moraine. Three (in order of sequence) occur (1) north of Sheer Rd., (2) one mile SE of West Sand Lake, and (3) along Rt. 154 at Moule's Lake. All of these contacts are fed by eskers some of which are a mile in length.

5. Schodack Terrace. Extensively developed through the Town of Schodack. Kamey in part with large kettles and a few short eskers. Deltaic sediments exposed along the western edge.

6. Ice-margin deltas. Exposed at Hampton Park and one mile east of Rensselaer. Extensive gravel pits at both localities. Expecially good bottomset structures at the latter.

7. Superglacial kame terrace and ground-laid ice-border outwash gravels are extensively exposed in a pit south of Williams Rd., North Greenbush. Terrace is continuous south to Defreestville where it terminates in a small delta.

8. Lacustrine varved clays with interbedded sands underlie a large area west of Rt. 4 and the Boston and Albany tracks. Good exposures are limited but occur along the entrance road to the paper company just north of Castleton, along Mill Creek north of Rysedorph Hill, and along Spring Street where about 35 feet of clay overlying gravel is exposed in a pit.

9. Beaches. The Lake Albany beach is well developed, with frequent storm ridges, at (1) one mile SE of South Schodack, (2) along the W edge of the Schodack terrace between Brookview and East Greenbush, and (3)from Defreestville E of Rt. 4 north along Blooming Grove Rd. Gravel pits provide cross-sections through the beach at all of these locations.

10. Peat bogs are common throughout the area. Peat is presently being dug from a bog one mile SE of West Sand Lake.

11. River terraces are best developed along the Poestenkill between Eagle Mills and Troy, and also along the Wynantskill in Albia.

12. Post-glacial rock gorges with falls are found on the Poestenkill near Pawling Ave. in Troy, on the Wynantskill along the Airport Rd. in Troy, and on Mill Creek along Rt. 151 near Rensselaer.

13. Promontories at Teller Hill near Sherwood Park, at Rysedorph Hill, and at Prospect Park in Troy offer panoramic views of the Hudson Valley.

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NOTES ON TRIP A